Consistent left gaze bias in processing different facial cues

Kun Guo, Claire Smith, Kathryn Powell, Kelly Nicholls

School of Psychology, University of Lincoln, Lincoln, LN6 7TS, UK

Short title:

Gaze asymmetry in face viewing

Corresponding Author:

Dr. Kun Guo

School of Psychology, University of Lincoln, Lincoln, LN6 7TS, UK

Email address: kguo@lincoln.ac.uk

Tel: +44-1522-886294

Fax: +44-1522-886026

Abstract

While viewing faces, humans often demonstrate a natural gaze bias towards the left visual field, that is, the right side of the viewee's face is often inspected first and for longer periods. Previous studies have suggested that this gaze asymmetry is part of the gaze pattern associated with face exploration, but its relation with perceptual processing of facial cues is unclear. In this study we recorded participants' saccadic eye movements while exploring face images under different task instructions (free-viewing, judging familiarity and judging facial expression). We observed a consistent left gaze bias in face viewing irrespective of task demands. The probability of the first fixation and the proportion of overall fixations directed at the left hemiface were indistinguishable across different task instructions or across different facial expressions. It seems that the left gaze bias is an automatic reflection of hemispheric lateralisation in face processing, and is not necessarily correlated with the perceptual processing of a specific type of facial information.

Keywords: Gaze bias, Faces, Task demands, Human

Introduction

Although our facial configuration is more or less symmetrical along the vertical axis, we are more likely to use facial cues contained in the right side of the owners' face (left side of the viewed face from viewer's perspective) to facilitate perceptual judgement of gender, age, identity, expression, likeness and attractiveness (Brady et al. 2005; Burt and Perrett 1997; Butler et al. 2005; Gilbert and Bakan 1973). For instance, when asked to label facial expression of a briefly presented chimeric face, in which the left and right side of the viewed face differ in facial expressions, viewers tend to base their decision more frequently on the visual input from the hemiface appearing in their left visual field (left hemiface). This left perceptual bias in face perception is often accompanied by a left gaze bias (LGB) when free eye movements are allowed in face exploration (Bulter et al. 2005; Mertens et al. 1993; Philips and David 1997). That is, the left hemiface is often inspected first and/or for longer periods.

With a novel and complimentary 'bubbles technique' in which participants perform face recognition or gender identification task by viewing each face through a set of simultaneously presented, randomly allocated small Gaussian windows distributed across the face, researchers also observed that local facial features within the left hemiface (e.g. the left eye) tend to become diagnostic earlier than their counterparts within the right hemiface (Schyns et al. 2002; Vinette et al. 2004). Taken together, it seems that we can allocate attention quicker or are more sensitive to local facial cues contained in the left hemiface.

The LGB in face exploration is related to neither handedness nor eye dominance (Leonards and Scott-Samuel 2005). Although the spatial attention bias is to the left visual field and in some cultures, a well practised left-to-right directional scanning bias (i.e. reading) may contribute to this gaze asymmetry (Heath et al. 2005; Nicholls and Roberts 2002; Niemeier et al. 2007; Rhodes 1986; Vaid and Singh 1989), it is often argued that a right hemisphere advantage in face processing is the underlying mechanism (Burt and Perrett 1997; Butler et al. 2005). Previous neurological and neuroimaging studies have consistently demonstrated that the face perception is preferentially lateralized in the right hemisphere. Compared to the left hemisphere, patients with the right hemisphere damage are more likely to be impaired in facial identity and emotion recognition (e.g. De Renzi et al. 1994), and normal volunteers have greater activation in face-sensitive cortical areas (e.g. fusiform face area, occipital face area and posterior superior temporal sulcus) within the right hemisphere when viewing faces (e.g. Gauthier et al. 2000; Kanwisher et al. 1997). Given that the right hemisphere receives visual input from the left visual field, it seems reasonable to hypothesise that the LGB in face exploration is related to the right hemisphere bias in face processing. This hypothesis is further supported by recent observations that the LGB is most evident in viewing upright faces, but is less or not evident at all in viewing inverted faces (face inversion would dramatically impair the efficiency of normal face processing) and symmetric non-face object or landscape images (Guo et al. 2009; Leonards and Scott-Samuel 2005).

Interestingly, this face-related LGB is not restricted to human faces or human viewers. A recent study observed a consistent initial gaze bias when human participants free-viewing human, monkey, dog and cat faces (Guo et al. 2010). The gaze asymmetry also occurs in non-human species such as rhesus monkeys (*Macaca mulatta*) and domestic dogs (*Canis familiaris*). In some animals it is even species-sensitive. For instance, pet dogs only demonstrated a LGB towards human faces, but not towards monkey or dog faces (Guo et al. 2009). Such observations imply a broader adaptive value of this natural gaze asymmetry in social species.

Although the LGB has been suggested by recent studies as the part of gaze pattern associated with face exploration, its contribution to the perceptual processing of facial information is still unclear. When a face is initially presented within a viewer's central visual field, the left hemiface is projected to the face-sensitive right hemisphere, where its saliency is more readily evaluated. Hence the LGB could be initiated by the gist perception of facial configuration in an automatic fashion to direct viewer's attention to the left hemiface because of its increased saliency. Alternatively, considering that the left and right hemiface can transmit the same type of facial cues in different intensity and/or speed (e.g. evoked anger is expressed more intensely in our right hemiface; Indersmitten and Gur 2003), the LGB could be actively engaged in face processing for the accurate and efficient detection or recognition of specific facial cues.

To examine the potential contribution of the LGB in face processing, in this exploratory study we compared participants' left/right gaze distribution when inspecting face images with different task instructions commonly used in studies of face perception (i.e. free-viewing, judging familiarity and judging facial expression). Facial identity and facial expression are two extensively studied facial cues. Bruce and Young's influential cognitive model on face perception (1986) proposed that after an initial facial structural encoding, facial expression and facial identity are processed along two separate pathways. This model is partly supported by brain-imaging observations that a distributed neural network is engaged in face perception in which different brain regions are associated with processing identity and expression cues (e.g. Gobbini and Haxby 2007). Recent eye tracking studies also reported that our gaze allocation to different facial regions is systematically manipulated by task demands of judging identity and expressions. Participants scanned the upper-face more than the lower-face in face identification task but the lower-face more than the upper-face in expression judgment task (Malcolm et al. 2008). Accordingly, if the LGB is associated with analyzing specific facial information, then different cognitive demands may initiate different patterns of gaze asymmetry. If, on the other hand, the LGB is "an automatic, internally driven initiation of the saccadic exploration of faces" (Leonards and Scott-Samuel 2005), then different cognitive demands should not affect the pattern of this gaze asymmetry.

Material and methods

30 undergraduate psychology students (10 male, 20 female), age ranging from 18 to 27 with the mean of 20.5±2.2 (Mean±SD), volunteered to participate in this study in return for course credit. All participants have uncorrected normal visual acuity. Informed consent was obtained from each participant, and all procedures complied with the World Medical Association Helsinki Declaration as revised in October 2008.

Digitized grey-scale face images were presented through a ViSaGe graphics system (Cambridge Research Systems) and displayed on a high frequency non-interlaced gamma-corrected colour monitor (1024 × 768 pixels, 30.0 cd/m^2 background luminance, 100 Hz frame rate, Mitsubishi Diamond Pro 2070SB). At a viewing distance of 57 cm the monitor subtended a visual angle of 40 × 30°.

Sixty face images were arranged into 3 presentation blocks with different task instructions (free viewing, judging face familiarity and judging facial expression). In each block, 20 faces had equal proportion in gender, familiarity and facial expression: 10 male and 10 female faces, 10 familiar and 10 unfamiliar faces, 10 neutral and 10 expressive (5 happy and 5 angry) faces. The unfamiliar faces were sampled from AR face database (Martinez and Benavente 1998; see Fig. 1A for examples), and familiar faces were sampled from internet and were chosen from those celebrities with frequent media exposures. We chose face images carefully to make sure that no visible facial marks existed in one side of the face, and all local facial features (e.g. shape of the eyes, ears, mouth corners) within the left and right hemiface were more or less symmetrical. The faces were gamma-corrected and displayed once in a random order at the centre of the screen with a resolution of 600 × 600 pixels (22 × 22°).

During the experiments the participants sat in a chair with their head restrained by a chin rest, and viewed the display binocularly. To calibrate eye movement signals, a small red fixation point (FP, 0.3° diameter, 15 cd/m^2 luminance) was displayed randomly at one of 9 positions (3 × 3 matrix) across the monitor. The distance between adjacent FP positions was 10°. The participant was instructed to follow the FP and maintain fixation for 1 sec. After the calibration procedure, the trial was started with an FP displayed on the centre of monitor (also the centre of the successively presented face). If the participant maintained fixation for 1 sec (i.e. the eye position was within 1° of the FP), the FP disappeared and an image was presented for 3 sec. For each presentation block, the participant viewed the faces with the task instruction of "viewing faces as you normally do" or "judging face familiarity with an answer of yes or no" or "judging facial expression with an answer of neutral, happy or angry". When required to make the fame or expression judgement, the participants had to give verbal response as soon as the face image disappeared. No reinforcement was given during this procedure and the inter-trial interval was set to 2 sec. The order of the presentation block and task instruction was randomised and counterbalanced for each participant, and a short break was encouraged after each presentation block. All participants completed 3 presentation blocks, and correctly identified all familiar faces in the familiarity judgement block and correctly labelled the facial expressions in the expression judgement block.

Horizontal and vertical eye positions were measured using a Video Eyetracker Toolbox with 50 Hz sampling frequency and up to 0.25° accuracy (Cambridge Research Systems). The software developed in Matlab computed horizontal and vertical eye displacement signals as a function of time to determine eye velocity and position. Saccadic eye movements were detected on the basis of their spatiotemporal characteristics. A sample belonged to a saccade if the eye displacement was greater than 0.2° at a velocity of faster than 20 deg/s. Fixation locations were then extracted from raw eye tracking data using velocity (less than 0.2° eye displacement at a velocity of less than 20°/s) and duration (greater than 50 ms) criteria (Guo et al. 2006).

For each trial we measured the direction of the first saccade (towards the left or right hemiface) after image presentation, and the number of fixations within the left and right hemiface as a percentage of total number of fixations within the whole face sampled in this trial. A lateralisation index, (R-L)/(R+L), was then calculated to assess the extent of the LGB for both the first saccade and overall fixation distribution. R and L represent the number of rightward and leftward initial saccades, or the proportion of fixations within the left and right hemiface. An index of 0 indicates no gaze bias, whereas a score between -1 and 0 indicates a LGB.

Results

Irrespective of the task instructions, our participants demonstrated a consistent LGB during face exploration. In comparison with the right hemiface, on average the left hemiface had a much higher probability (≥66%) to be the first saccade destination (see Fig. 1B for the first saccade allocation across all the trials) and attracted more fixations during 3-second image presentation time (≥57% of total fixations per image). One-sample t-test (testing against 50%) revealed that such leftward bias for the first saccade direction and overall fixation distribution was clearly above-chance (all $ps < 0.02$). The task instructions, on the other hand, had no significant impact on the lateralisation index (the magnitude of the leftward bias) for both the first saccade direction (one way repeated-measures ANOVA, $F_{2,58} = 0.52$, $p = 0.6$; Fig. 1C) and overall fixation distribution ($F_{2,58} = 1.51$, $p = 0.23$). It seems that the face-related LGB is not sensitive to the explicit cognitive demand in processing of specific facial information.

Analyzing sequential fixation placement between the left and right hemiface could provide valuable information about the temporal organisation of the LGB in face processing. To examine whether spatial allocation of the sequential fixations was influenced by different task instructions, we compared the first five fixation placements in each image, and plotted the lateralisation index as a function of fixation sequence in Fig. 2A. 5 (fixation sequences) × 3 (task instructions) ANOVA revealed that the left hemiface had a higher probability to be inspected at the initial stage of face viewing, but this probability was decreased after the first fixation ($F_{4,116} = 3.61$, $p = 0.008$, $\eta_p^2 = 0.11$). The task instructions, again, had no significant influence on sequential fixation allocation on the left hemiface ($F_{2,58} = 2.03$, $p = 0.14$). In addition, no significant interaction was observed between fixation sequence and task instructions ($F_{8,232} = 0.72$, $p = 0.68$), suggesting that the temporal organisation of the LGB in face viewing was not affected by different task instructions.

Fig. 2A clearly demonstrated that the degree of the LGB was more evident for the first fixation than the subsequent fixations in face viewing. To examine whether the LGB in overall fixation distribution was simply caused by the strongest leftward bias of the initial fixation, we re-analyzed the overall fixation distribution without the first one (ensuing fixation distribution) for each trial. One-sample t-tests revealed even when the first fixation was not taken into account, the left hemiface still attracted above-chance proportion of the fixations in face viewing (>55% of total fixations per image; all $ps < 0.03$). The task instructions, on the other hand, had no significant impact on the lateralisation index ($F_{2,58} = 1.93$, $p = 0.15$; Fig. 2B). It seems that both the first and successive fixations contributed to the development of the LGB in face exploration.

Among various information a face can provide (e.g. an individual's gender, age, familiarity, intention and mental state), facial expression can be transmitted in different intensity at different speed between the left and right hemiface (Borod et al. 1997; Indersmitten and Gur 2003). Considering that (1) in this study the image set used for each task had equal proportion of neutral and expressive faces, (2) the task instruction had no significant influence on the LGB, and (3) the facial expression can be processed as quickly as 100 ms or even less (Kirouac and Doré 1984; Willis and Todorov 2006); we re-grouped each participant's data sampled from 60 face viewing trials according to the face valence (neutral, angry and happy expressions) to examine whether the LGB was influenced by different facial expressions. One way repeated-measures ANOVA revealed non-significant effect of the facial expressions on the first saccade direction towards the left hemiface ($F_{2,58} = 1.34$, $p = 0.27$; Fig. 3A), ensuing leftward fixation distribution (overall fixation distribution without the first fixation, $F_{2,58} = 0.42$, $p = 0.66$; Fig. 3B), and overall leftward fixation distribution ($F_{2,58} = 0.24$, $p = 0.79$). It seems that the proportion of the first fixation (>68%), ensuing fixations (>56%) and overall fixations (>59%) directed at the left hemiface were not significantly different across three facial expressions.

Given that we have not found a clear impact of the task instructions on the LGB, it could be argued that our participants might simply not have engaged in these tasks. This is unlikely because our analysis of behavioural responses showed that all participants have correctly identified familiar faces in the familiarity judgement block and correctly labelled facial expressions in the expression judgement block. Alternatively, the different task instructions may have engaged the same scanning strategy to sample relevant facial information for different task demands. To investigate this possibility, we examined whether the fixation distribution within a face was affected by different task instructions. As majority of the fixations (>87%) were directed at key internal facial features (i.e. eyes, nose and mouth) in face exploration, we compared the proportion of fixations allocated at each of these key features between task demands (Fig. 4A). While determining fixation allocation within a face, the criteria adopted from Barton et al. (2006) were used to define boundaries between local facial features and to ensure equal size of the key features across different faces. The proportion of the area of a particular facial feature relative to the whole image was further subtracted from the proportion of the fixations directed at that facial feature in a given trial. Any difference in fixation distribution above zero means that this particular facial feature has attracted more fixations than predicted by a uniform looking strategy (Dahl et al. 2009; Guo et al. 2010). 3 (task instructions) × 3 (local facial features) ANOVA showed significant main effects of task instruction ($F_{2,58} = 7.45$, $p = 0.001$, $\eta_p^2 = 0.20$) and local facial feature ($F_{2,58} = 38.56$, $p < 0.001$, $\eta_p^2 = 0.57$). Specifically, the participants directed significantly higher proportion of fixations towards the mouth region in the expression judgements (13% of normalised total fixations within a trial) than in the free viewing (5%) and familiarity judgements (6%) (post hoc t-test, $p<0.001$). The eyes and nose region, on the other hand, attracted the same proportion of fixations in different viewing conditions.

As the task instructions only modulated the amount of fixations allocated at the mouth region, we further examined whether the LGB for the mouth fixations could be affected by the task demands (Fig. 4B). On average, the left mouth attracted significantly more fixations than the right mouth under all three task instructions (>63% of total mouth fixations; all *ps* < 0.01), but the lateralisation index of the mouth fixations was indistinguishable across different viewing conditions (ANOVA, $F_{2,58} = 0.13$, $p = 0.88$). Taken together, it seems that different task instructions could induce different gaze distribution within the internal facial regions, but identical gaze distribution between the left and right hemiface.

Discussion

Using images of human faces, previous studies have demonstrated a clear LGB associated with face viewing. This gaze asymmetry normally occur as early as the first fixation if the face is presented at the central vision (e.g. Bulter et al. 2005; Guo et al. 2010; Mertens et al. 1993; Philips and David 1997), or the second fixation if the face is presented at parafovea or periphery region (e.g. van Belle et al. 2010). The LGB is not evident at all or is significantly reduced in viewing of symmetric non-face object or landscape images (Guo et al. 2009; Leonards and Scott-Samuel 2005), suggesting it is dissociable from general leftward bias in the spatial attention as revealed by studies on pseudoneglect with line bisection or similar tasks (e.g. Jewell and McCourt 2000). The LGB is further sensitive to the face orientation (i.e. face inversion would abolish or significantly decrease the magnitude of the LGB) (Guo et al. 2009; Leonards and Scott-Samuel 2005), suggesting it could be associated with the face perception. Indeed in a few separate experiments with chimeric faces or full-face photos as visual stimuli, participants showed the LGB while performing memory task (Mertens et al. 1993), gender categorization (Bulter et al. 2005) or expression categorization task (Philips and David 1997). In this study with carefully-controlled realistic face pictures, we directly compared this gaze asymmetry while the same group of participants explored these faces with different cognitive demands. We observed that the LGB is not restricted to the free-viewing task (e.g. Guo et al. 2009, 2010) or to the processing of a specific type of facial information. As a population our participants demonstrated the consistent LGB in free-viewing faces, judging face familiarity and labelling facial expressions, suggesting that the LGB could be intimately tied to the normal eye scanning patterns in the processing of various facial cues.

Naturally the follow-up question would be the role of the LGB in face perception. Is it an additional reflection of the hemispheric lateralisation in face processing? Or is it part of the gaze pattern associated with sampling salient/relevant facial information from local facial features according to the ongoing cognitive demand? A recent study by Butler at al. (2005) shed some light into this question. When asked to judge the gender of a chimeric face, the first fixation tended to be directed at the left hemiface irrespective of perceptual decision. Within a trial, the overall fixation distribution on the left and right hemiface did not show a directional bias, but on trials where participants based their decision on gender cues contained in the left side of the chimeric face, they fixated more often and/or longer on the left hemiface. The authors suggested that the initial leftward saccade reflects the right hemisphere bias in face processing, and could be initiated by the gist perception of facial configuration in an automatic fashion regardless of detailed facial information (Butler at al. 2005). The leftward bias for overall fixation pattern, on the other hand, could be perception-dependent and associated with acquiring relevant facial cues. However, due to the nature of the chimeric faces used in their study, the degree of the LGB for overall fixation distribution could be underestimated as the participants could be puzzled by the conflicting gender cues contained in the left and right hemiface and hence directed equal share of fixations on both side of faces.

With realistic face pictures, in this study we observed a consistent leftward bias for both the initial saccade and overall fixation distribution irrespective of ongoing perceptual processes. The stronger leftward bias at the initial stage of face viewing (Fig. 1D) suggests that the processing of the gist facial configuration plays a central role in developing the LGB. Furthermore, its indistinguishable magnitude across different task instructions suggests that the LGB is not sensitive to the acquiring or processing of specific facial information, and may not be perception-dependent. In other words, it seems that the LGB is an automatic reflection of hemispheric lateralisation in face processing, and is not necessarily correlated with the perceptual processing of a specific type of facial information.

In addition to processing facial information such as gender and familiarity, the right hemisphere is also dominant in processing emotional cues (Haxby et al. 2000). Compared with judging gender or identity of a chimeric face, observers often demonstrate a stronger left perceptual bias in judging facial expression of a chimeric face (Coolican et al. 2008; Luh et al. 1991; Mattingley et al. 1993), indicating that the cognitive demand for processing facial expressions could enhance the left perceptual bias in face perception. Contrary to its influence on the left perceptual bias, here we observed that processing facial expressions had no enhancement effect on the LGB. The magnitudes of the LGB for both the initial and overall fixation distributions were indistinguishable across the tasks of free-viewing, familiarity judgement and expression judgement, and across the faces with neutral, happy and angry expressions. Although there are other factors that may account for this discrepancy between the left perceptual bias and the LGB, such as differences in facial structures (i.e. chimeric faces vs realistic faces) and different facial expressions used in different studies which could induce different patterns of functional brain asymmetry (Murphy et al. 2003), it is also possible that the LGB is predominantly induced by the general facial structures or configurations, and does not have to be correlated with the left perceptual bias.

Reference

Barton, J. J. S., Radcliffe, N., Cherkasova, M. V., Edelman, J., & Intriligator, J. M. (2006). Information processing during face recognition: the effects of familiarity, inversion, and morphing on scanning fixations. Perception, 35, 1089-1105.

Borod, J. C., Haywood, C. S., & Koff, E. (1997). Neuropsychological aspects of facial asymmetry during emotional expression: a review of the normal adult literature. Neuropsychology Review, 7, 41–60.

Brady, N., Campbell, M., & Flaherty, M. (2005). Perceptual asymmetries are preserved in memory for highly familiar faces of self and friend. Brian and Cognition, 58, 334-342.

Bruce, V., & Young, A. (1986). Understanding Face Recognition. British Journal of Psychology, 77, 305–327.

Burt, D. M., & Perrett, D. I. (1997). Perceptual asymmetries in judgements of facial attractiveness, age, gender, speech and expression. Neuropsychologia, 35, 685-693.

Butler, S., Gilchrist, I. D., Burt, D. M., Perrett, D. I., Jones, E., & Harvey, M. (2005). Are the perceptual biases found in chimeric face processing reflected in eye-movement patterns? Neuropsychologia, 43, 52-59.

Coolican, J., Eskes, G. A., McMullen, P. A., & Lecky, E. (2008). Perceptual biases in processing facial identity and emotion. Brian and Cognition, 66, 176-187.

Dahl, C. D., Wallraven, C., Bulthoff, H. H., & Logothetis, N. K. (2009). Humans and macaques employ similar face-processing strategies. Current Biology, 19, 509-513.

De Renzi, E., Perani, D., Carlesimo, G. A., Silveri, M. C., & Fazio, F. (1994). Prosopagnosia can be associated with damage confined to the right hemisphere—an MRI and PET study and a review of the literature. Neuropsychologia, 8, 893–902.

Gauthier, I., Tarr, M. J., Moylan, J., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). The fusiform "face area" is part of a network that processes faces at the individual level. Journal of Cognitive Neuroscience, 12, 495–504.

Gilbert, C., & Bakan, P. (1973). Visual asymmetry in perception of faces. Neuropsychologia, 11, 355-362.

Gobbini, M. I., & Haxby, J. V. (2007). Neural systems for recognition of familiar faces. Neuropsychologia, 45, 32-41.

Guo, K., Mahmoodi, S., Robertson, R. G., & Young, M. P. (2006). Longer fixation duration while viewing face images. Experimental Brain Research, 171, 91-98.

Guo, K., Meints, K., Hall, C., Hall, S., & Mills, D. (2009). Left gaze bias in humans, rhesus monkeys and domestic dogs. Animal Cognition, 12, 409-418.

Guo, K., Tunnicliffe, D., & Roebuck, H. (2010). Human spontaneous gaze patterns in viewing of faces of different species. Perception, 39, 533-542.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. Trends in Cognitive Science, 4, 223-233.

Heath, R. L., Rouhana, A., & Ghanem, D. A. (2005). Asymmetric bias in perception of facial affect among Roman and Arabic script readers. Laterality, 10, 51-64.

Indersmitten, T., & Gur, R. C. (2003). Emotion processing in chimeric faces: hemispheric asymmetries in expression and recognition of emotions. Journal of Neuroscience, 23, 3820-3825.

Jewell, G., & McCourt, M. E. (2000). Pseudoneglect: a review and meta-analysis of performance factors in line bisection tasks. Neuropsychologia, 38, 93-110.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. Journal of Neuroscience, 17, 4302–4311.

Kirouac, G., & Doré, F. Y. (1984). Judgment of facial expressions of emotion as a function of exposure time. Perceptual and Motor Skills, 59, 147–150.

Leonards, U., & Scott-Samuel, N. E. (2005). Idiosyncratic initiation of saccadic face exploration in humans. Vision Research, 45, 2677-2684.

Luh, K. E., Rueckert, L. M., & Levy, J. (1991). Perceptual asymmetries for free viewing of several types of chimeric stimuli. Brain and Cognition, 16, 83-103.

Malcolm, G. L., Lanyon, L. J., Fugard, A. J. B., & Barton, J. J. S. (2008). Scan patterns during the processing of facial expression versus identity: An exploration of task-driven and stimulus-driven effects. Journal of Vision, 8(8):2, 1-9.

Martinez, A. M., & Benavente, R. (1998). The AR Face Database. CVC Technical Report #24, June 1998

Mattingley, J. B., Bradshaw, J. L., Phillips, J. G., & Bradshaw, J. A. (1993). Reversed perceptual asymmetry for faces in left unilateral neglect. Brain and Cognition, 23, 145-165.

Mertens, I., Siegmund, H., & Grusser, O. J. (1993). Gaze motor asymmetries in the perception of faces during a memory task. Neuropsychologia, 31, 989-998.

Murphy, F. C., Nimmo-Smith, I., & Lawrence, A. D. (2003). Functional neuroanatomy of emotions: a meta-analysis. Cognitive, Affective, & Behavioral Neuroscience, 3, 207-233.

Nicholls, M. E. R., & Roberts, G. R. (2002). Can free-viewing perceptual asymmetries be explained by scanning, pre-motor or attentional biases? Cortex, 38, 113-136.

Niemeier, M., Stojanoski, B., & Greco, A. (2007). Influence of time and spatial frequency on the perceptual bias: evidence for competition between hemispheres. Neuropsychologia, 45, 1029-1040.

Philips, M. L., & David, A. S. (1997). Viewing strategies for simple and chimeric faces: An investigation of perceptual bias in normal and schizophrenic patients using visual scan paths. Brain and Cognition, 32, 225-238.

Rhodes, G. (1986). Perceptual asymmetries in face recognition. Brain and Cognition, 4, 197-218.

Schyns, P. G., Bonnar, L., & Gosselin, F. (2002). Show me the features! Understanding recognition from the use of visual information. Psychological Science, 13, 402–409.

Vaid, J., & Singh, M. (1989). Asymmetries in the perception of facial affect: Is there an influence of reading habits? Neuropsychologia, 27, 1277-1287.

van Belle, G., Ramon, M., Lefèvre, P., & Rossion, B. (2010). Fixation patterns during recognition of personally familiar and unfamiliar faces. Frontiers in Psychology, 1, 20.

Vinette, C., Gosselin, F., & Schyns, P. G. (2004). Spatio-temporal dynamics of face recognition in a flash: it's in the eyes. Cognitive Science, 28, 289-301.

Willis, J., & Todorov, A. (2006). First impressions: making up your mind after a 100-ms exposure to a face. Psychological Science, 17, 592-598.

Figure Caption

Figure 1. (A) Examples of face images used in the recording. (B) Overall distribution of the first fixation on a typical face. Each black dot represents the first saccade destination sampled from one face-viewing trial. (C) Lateralisation index of the initial saccade towards the left and right hemiface in free-viewing, judging familiarity and judging facial expression conditions. Error bars indicate 1 SEM.

Figure 2. (A) Lateralisation index of the first five fixations during free-viewing, familiarity judgement and expression judgement. (B) Lateralisation index of ensuing fixation distribution (overall fixation distribution without the first one) sampled in three different testing conditions. Error bars indicate 1 SEM.

Figure 3. Lateralisation index of the initial saccade (A) and ensuing fixation distribution (B) within faces of neutral, happy and angry expressions. Error bars indicate 1 SEM.

Figure 4. (A) Number of fixations directed at eyes, nose and mouth region as a percentage of the total number of fixations within whole face images. The pattern of fixation distribution was compared across free-viewing, judging familiarity and judging facial expression conditions. The proportion of fixations directed at each facial region was normalised according to the area of the facial region. Any difference in fixation distribution above zero means that this particular facial region was inspected more than predicted by a uniform looking strategy. (B) Lateralisation index of fixation distribution within the mouth region sampled in three different testing conditions. Errors bars indicate 1 SEM.

Figure 1

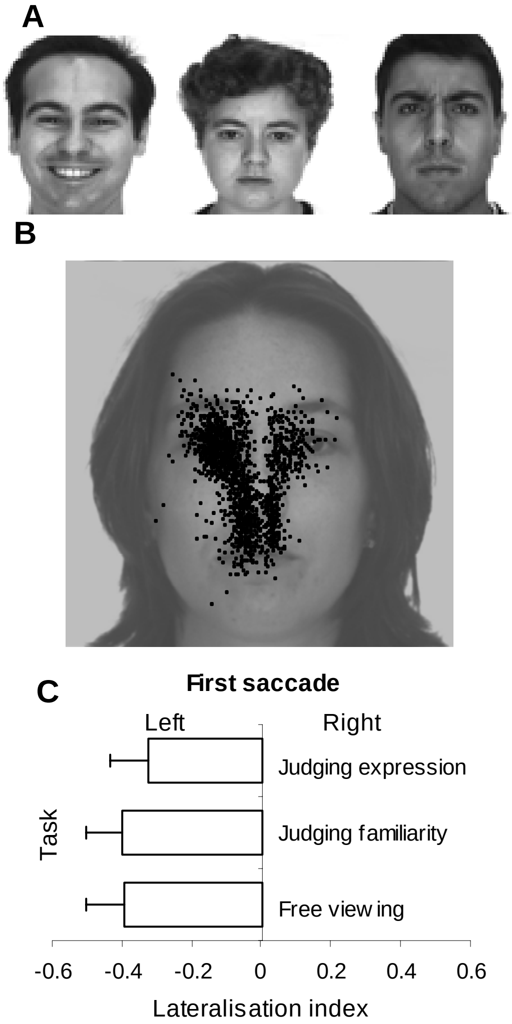

A
B
C
First saccade
Left
Right
Judging expression
Judging familiarity
Free view ing
Task
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Lateralisation index

Figure 2

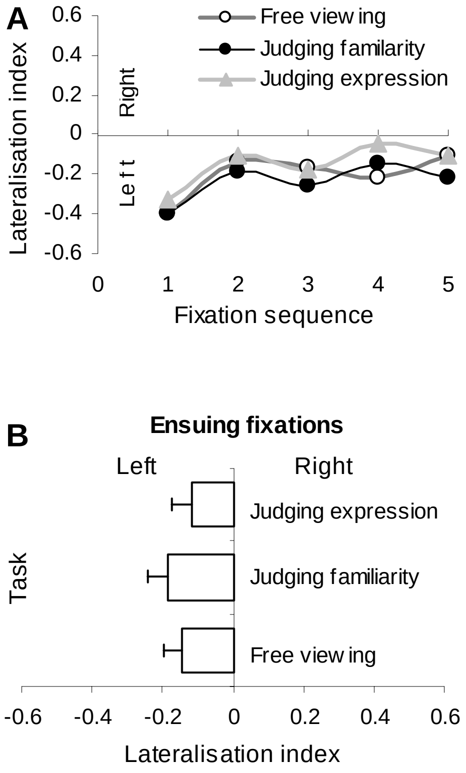

A
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Lateralisation index
Right
Left
0
1
2
3
4
5
Fixation sequence
Free viewing
Judging familarity
Judging expression
B
Ensuing fixations
Left
Right
Task
Judging expression
Judging familiarity
Free viewing
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Lateralisation index

Figure 3

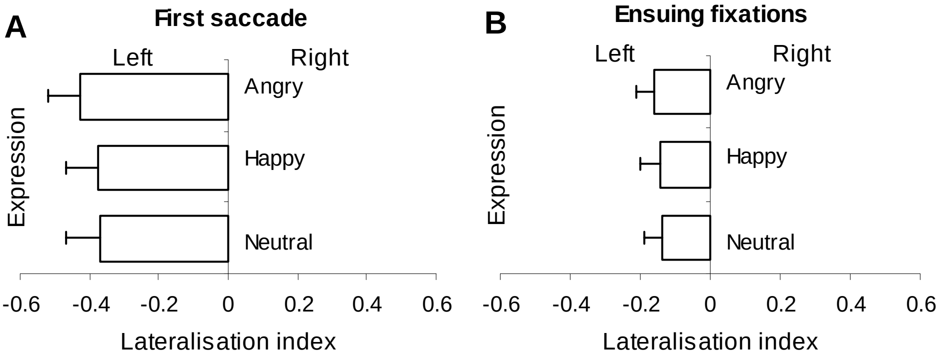
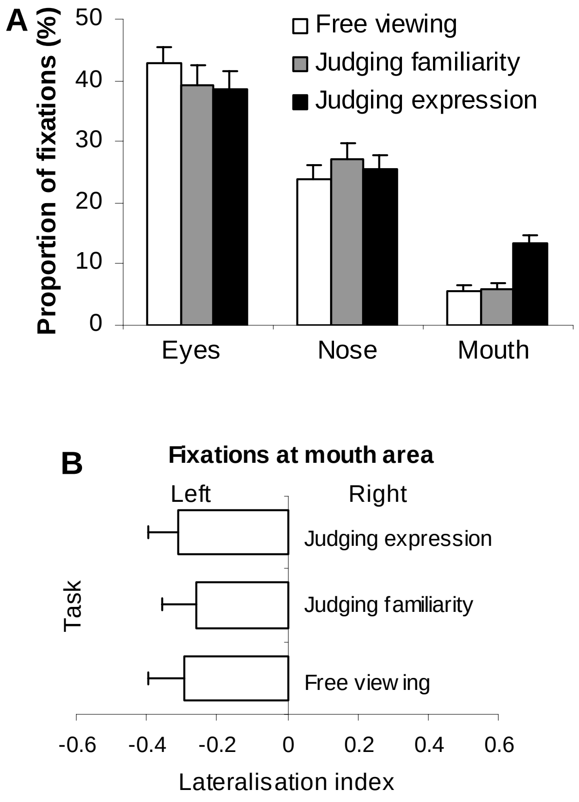

A
First saccade
Left
Right
Angry
Happy
Neutral
Expression
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Lateralisation index
B
Ensuing fixations
Left
Right
Angry
Happy
Neutral
Expression
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Lateralisation index

Figure 4


A
Proportion of fixations (%)
50
40
30
20
10
0
□ Free viewing
▨ Judging familiarity
■ Judging expression
Eyes
Nose
Mouth
B
Fixations at mouth area
Left
Right
Judging expression
Judging familiarity
Free viewing
Task
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
Lateralisation index